CROMER CYCLE DESICCANT-BASED COMBINED SYSTEM

INTEGRATED ENERGY SYSTEMS PEER REVIEW
May 1, 2002 – Nashville, Tennessee

P.I. - Charles J. Cromer, Ph.D.,P.E.
Florida Solar Energy Center
Co. P.I. - Arthur D. Hallstrom,P.E.
Trane Company

What Is Needed – A Combined Desiccant HVAC Product That Provides:

- Space Cooling/Heating with Fresh Air
- Increased Dehumidification Capacity – SHR's .5 to .4 ; leading to –
- Improved indoor comfort and air quality.
- Low first cost – similar to other HVAC dehumidification products (heat pipes).
- Use waste heat for energy saving.
- Improved energy efficiency providing reduced building and national energy use.

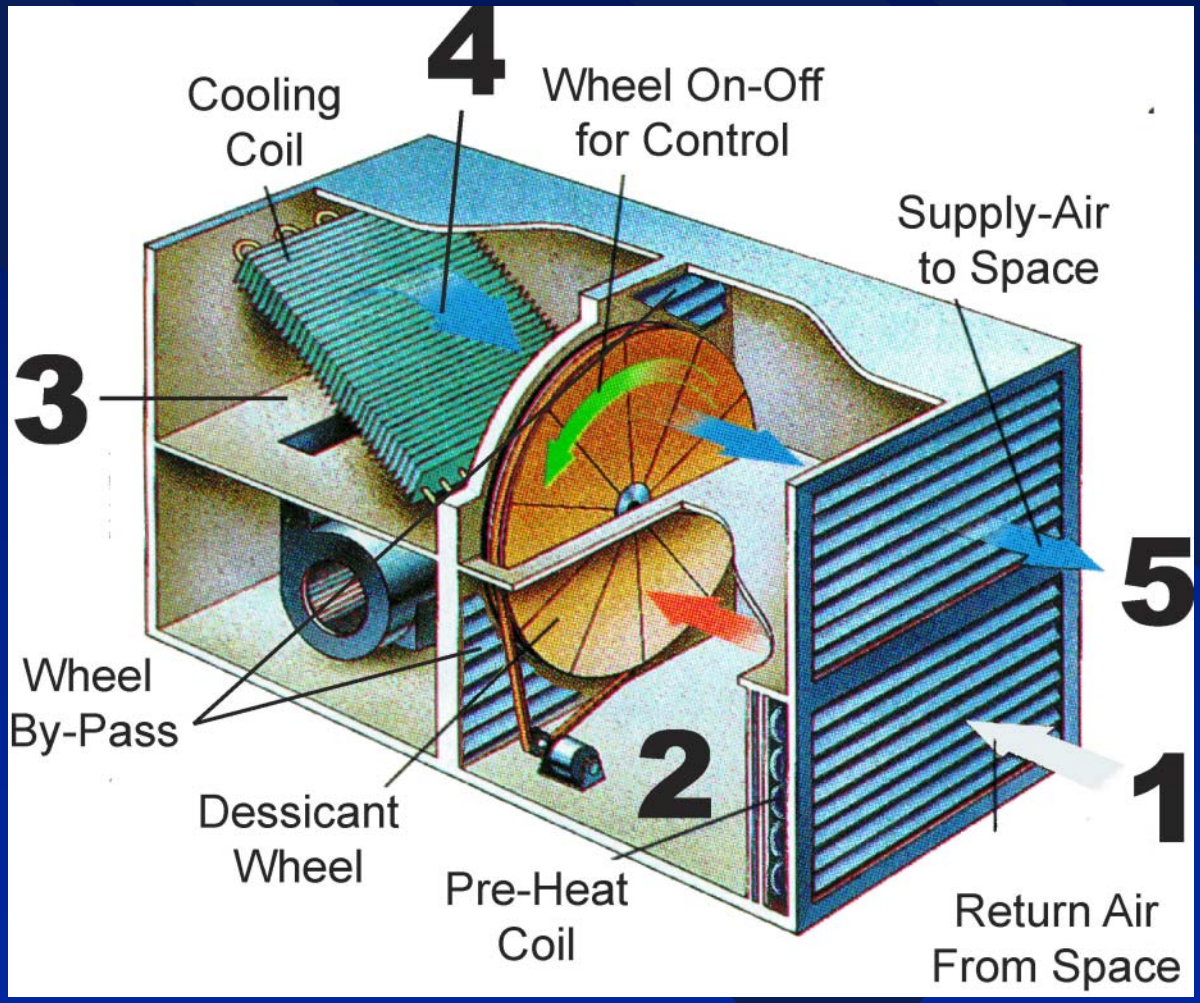
This breakthrough product is the Cromer Cycle Desiccant-Based Combined System:

Trane Active Cromer Cycle

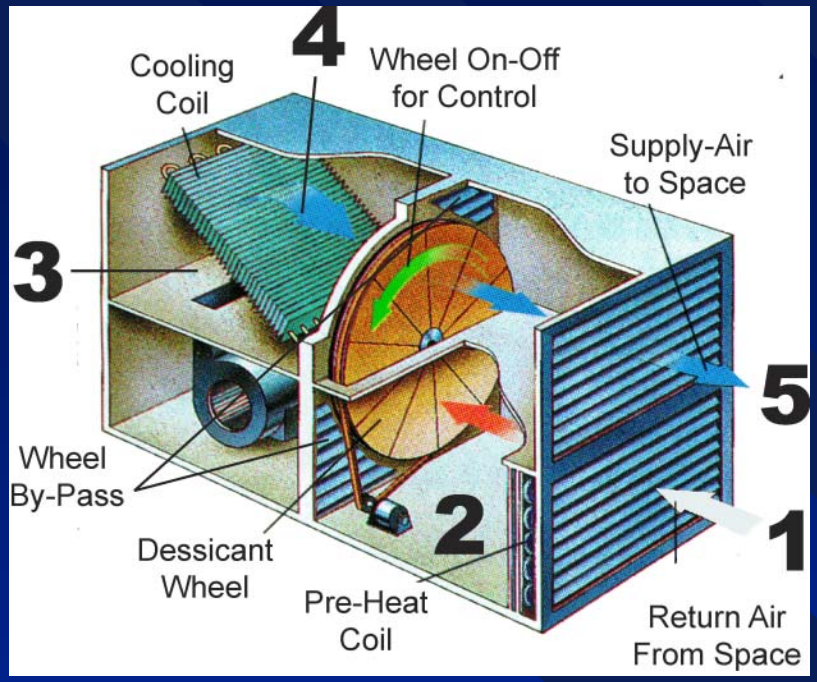
Project Objective

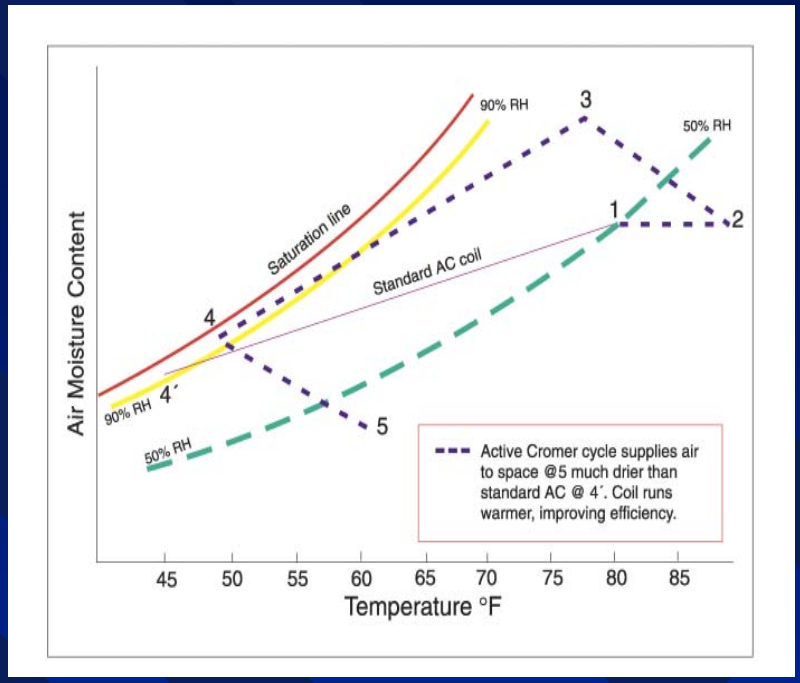
Complete the engineering effort needed to bring this product to the completion of two manufacturing prototypes, (10 and 20 ton) and test these for performance and energy savings.

Trane Active Cromer Cycle



Trane Active Cromer Cycle





- Desiccant wheel captures moisture from off the cold coil at 4 -5, transfers moisture to return air at 2-3. Double to triple the moisture removal of standard coil.
- Moisture that would have gone back to the space is trapped, then removed by cold coil at higher air conditioning efficiencies . . saving energy.
- Preliminary work shows major energy savings over gas fired desiccant, standard vapor compression dehumidifiers, reheat, heat pipes and other means of moisture control.

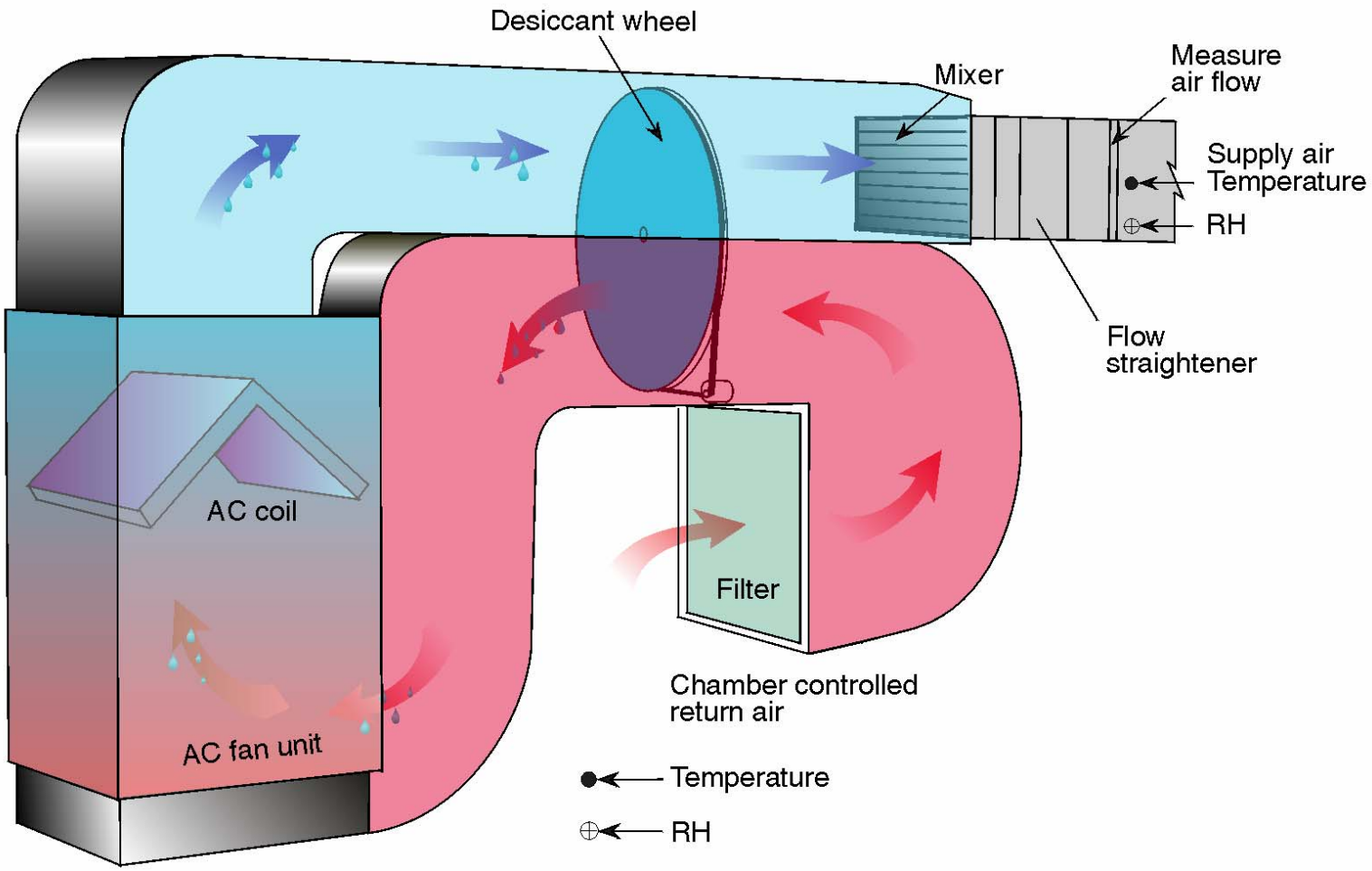
Prior Work Has Validated The Cycle

1. By Simulation
2. By Lab Test

Simulation Results (No Preheat)

Investigator	Model	LR	Comparison to Heat Pipes: Capacity	Comparison to Heat Pipes: Energy Saving
Dr. Cromer, UCF	DCSSMX1 (Collier)	40%	5.1%	10%
Drs. Nimmo & Collier, FSEC	DCSSMX2 (Collier)	52%	10.0%	10%
Drs. Chant & Jeter, Ga Tech.	PCP (Chant)	52%	12.6%	8%

Lab Test for Cromer Cycle Validation



Ducting in Lab

Results From Lab Test For Cromer Cycle Validation - 10 RPH

	Standard AC	Cromer Cycle	% Change
Latent Ratio, %	26.2	53.4	+103.8
Latent Cooling, Btu/hr	14,017	35,425	+152.7
Water, gal/hr	1.56	3.93	+153.2
Capacity, Btu/hr	53,590	66,328	+23.8
Capacity, Tons	4.467	5.527	+23.8
Watts - Ave over Hr	6709	5610	- 16.4
EER	7.99	11.82	+47.9
Air Flow, CF M	1524	1081	- 29.1

Cromer Cycle Validated By Previous Work

Major Milestones For This Project:

- **Define Hardware Concept:** a. market assessment, b. manuf. cost estimates, c. define control concepts.
- **Optimize Hardware:** a. bench testing for desiccant, b. full scale testing for performance.
- **Construct two manufactured prototypes.**
- **Define a MOT - to characterize performance.**
- **Independent Lab Test - to verify perf. targets.**
- **Simulate Market Applications - for comparisons and identification of primary markets.**

Performance Targets:

- 1. At 380 Cfm/ton, 80F/51RH inlet, product will provide 50% Latent Ratio (.5 SHR) (Wheel must transfer more than 10 grains/lb air).
- 2. At 380 Cfm/ton, 90F/37%RH inlet (10 degrees preheat), product will provide 60% Latent Ratio (.4 SHR) (Must xfer > 15 grains/lb air)
- 3. At 1 above, provide increased total cooling capacity (sensible + latent) over air-conditioner.
- 4. At 1 above, reduce energy use by 50% compared to reheat, 10% compared to heat pipe alternatives.

Project Team:

- Jim Sand: DOE, Oak Ridge National Laboratory – DOE Technical Administration
- Charlie Cromer: FSEC/UCF – Program Administration, Product Optimization
- Art Hallstrom: Trane – Admin. & Product Manufacture (Ronnie Moffitt, Jeff Moore)
- Jim Hurley: Airxchange – Desiccant Wheel (Bede Wellford, Don Steele, Larry Hoagland)
- Doug Kosar: U of I at Chicago – Simulations (Marek Czachorski)

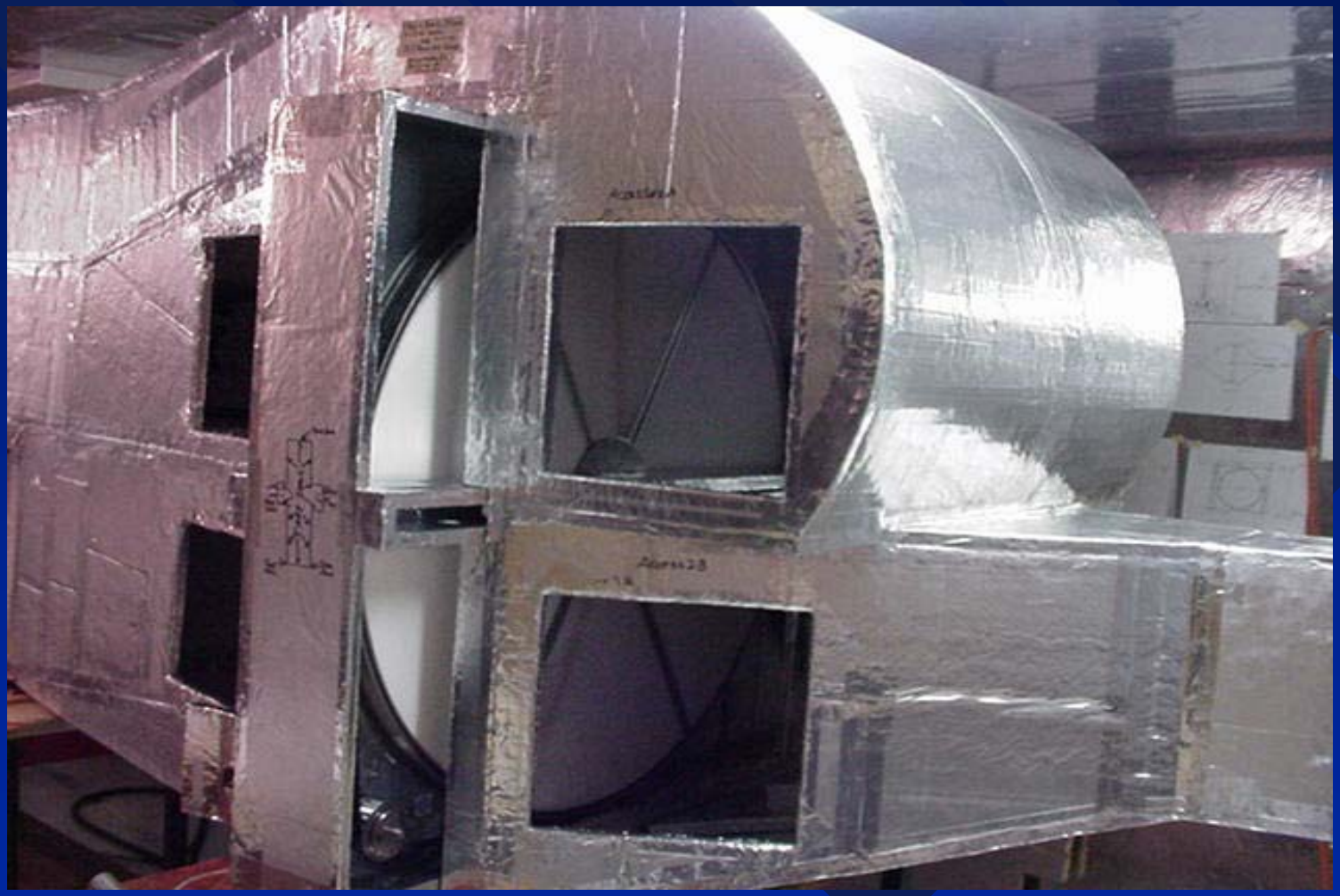
Program Activity To Go:

- Test Prototype 1 for performance equations.
- Simulate for comparison to alternatives for various applications and locations.
- Select first potential application market.
- Build Prototype 2.
- Define MOT for units.
- Test both prototypes in independent Lab.
- Followup program decision based on measured performance of prototypes and simulations.

Task Assignments For This Project:

- Define Hardware Concept: Lead Trane, input from FSEC, Airxchange.
- Optimize Hardware: Lead FSEC, input from Airxchange, Trane
- Construct two manufactured prototypes: Trane
- Define a MOT – Lead FSEC, input from Trane, Airxchange.
- Independent Lab Test – Intertek ETL
- Simulate Market Applications – Lead: U of Illinois at Chicago, input from Trane, FSEC.

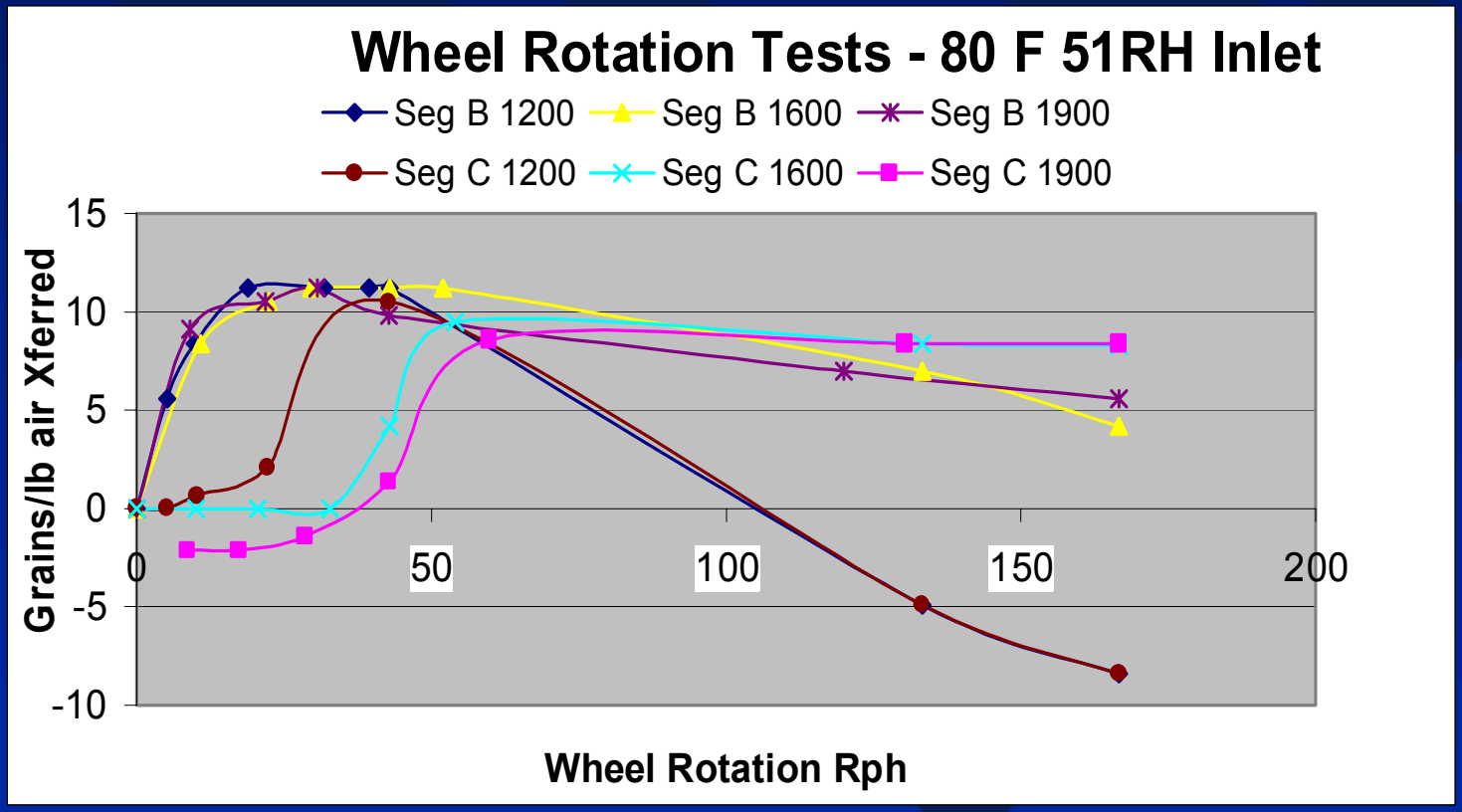
Program Activity Thus Far:
Bench Stand Set Up to Test Wheels



More Program Activity Thus Far:
Control Room For Test Stand

More Program Activity Thus Far:

Three wheels tested (A, B, C). Wheel B found to exceed moisture transfer targets. Rph optimized by first dirivitive of xfer equation set to = 0



More Program Activity Thus Far: Also Validated on "B" Wheel -

- Moisture exchange did not change much with change of air flow around optimum Rph.
- Moisture exchange did not change much with change of Rph around optimum Rph – 35 to 45 Rph.
- Moisture exchange > 10 grains at no preheat, >15 grains at 10 degree F preheat and > 20 grains at 15 degrees F preheat.

Primary Technical Barrier:

Develop a desiccant wheel that will respond well to the needed performance conditions, i.e. provide the moisture transfer targets.

This problem has been solved with the Airxchange Label B desiccant wheel.

More engineering effort is needed but no other technical barriers are evident.

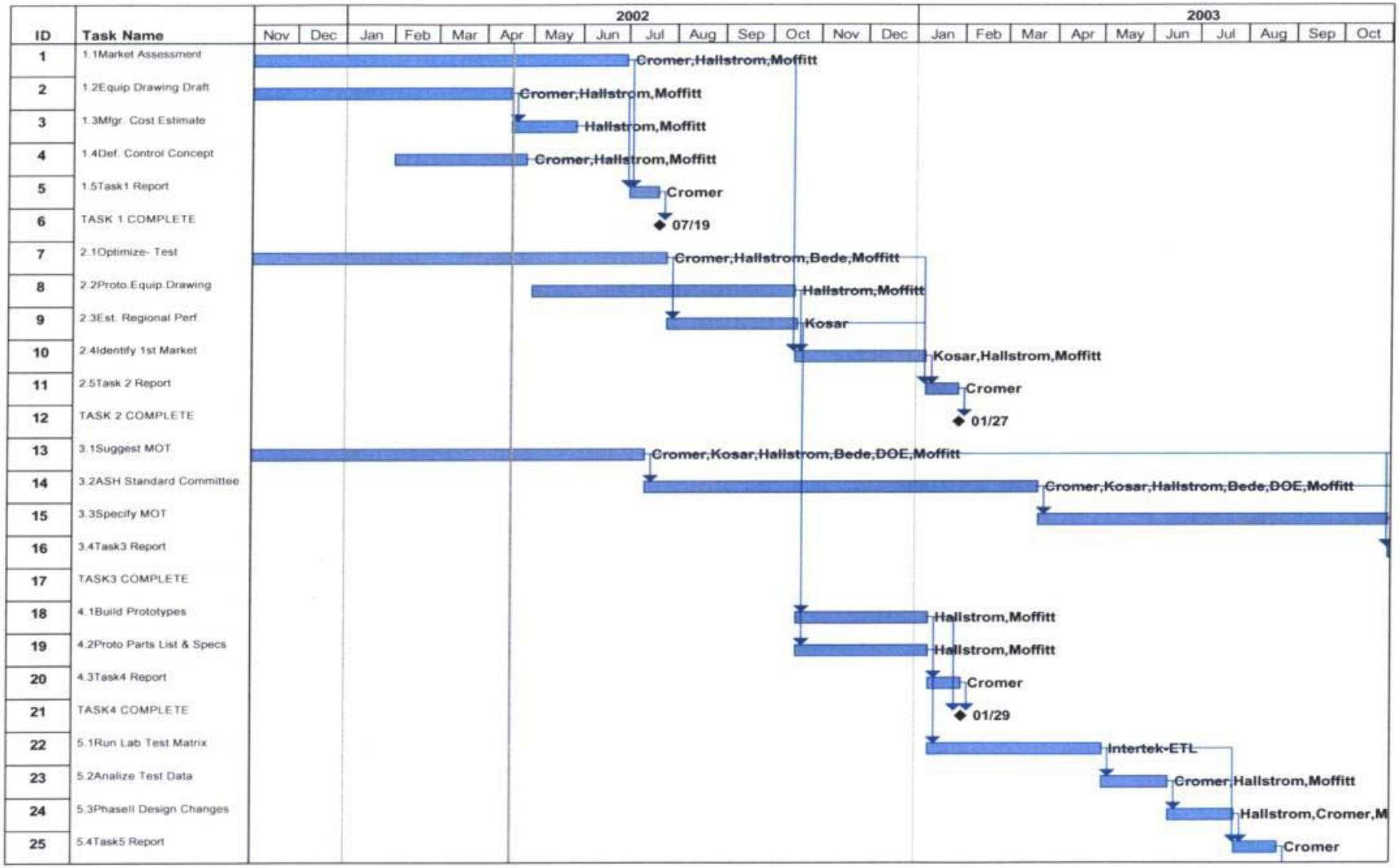
More Program Activity Thus Far:

Trane effort on the Market Survey has identified twelve specific market applications as appropriate for this technology: Schools, Office Buildings, Retail Buildings, Hotels, Restaurants, Museums- Libraries-Archives, Hospitals, Elder Care, Dormitories, Swimming Pools, Ice Rinks, Dry Air Storage, Laboratories.

More Program Activity Thus Far:

- First Trane Prototype design completed (10 ton).
- First Prototype is under construction – photo shows open access door to desiccant wheel.
- Control system has been defined.
- All component parts for first prototypes have been ordered.

Schedule of Tasks:



Program Activity To Go:

- Test Prototype 1 for performance equations.
- Simulate for comparison to alternatives for various applications and locations.
- Select first potential application market.
- Build Prototype 2.
- Define MOT for units.
- Test both prototypes in independent Lab.
- Followup program decision based on measured performance of prototypes and simulations.

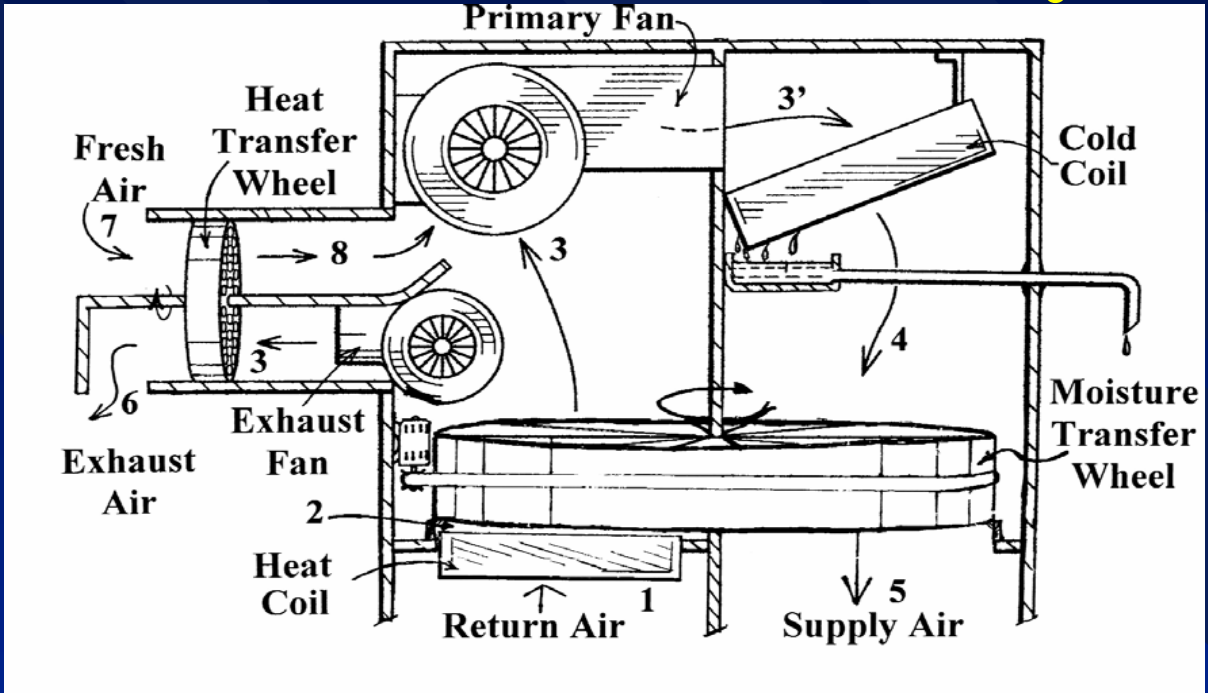
Program Summary
Trane Active Cromer Cycle

- This program represents development of a new "breakthrough" technology combining desiccants with HVAC systems and using waste heat.
- This program is performance based with target performance criteria.
- This program represents a model of a working public-private partnership combining efforts of National Lab, Universities, and Private Industry.
- This program provides significant leverage of DOE $.
- This program meets the National Energy Policy Development Group priority for improving energy efficiency for higher productivity per unit energy.

CROMER CYCLE
DESICCANT–BASED COMBINED SYSTEM

END

Trane Active Cromer Cycle



- Desiccant wheel captures moisture from off the cold coil at 4 -5 and transfers this moisture to return air at 2-3. Doubles to triples the moisture removal of the coil.
- Moisture that would have gone back to the space is trapped, then removed by cold coil at high air conditioning efficiencies . . saving energy.
- Preliminary work shows major energy savings over gas fired desiccant, standard vapor compression dehumidifiers and other means of moisture control.